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SMART VEST FOR MONITORING AND SUPPORT OF MEDICAL STAFF

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ABSTRACT

This paper is about the design and implementation of highly cost effective smart vest for electronic prescribing and administration system to control medical errors, prescribing errors, administration errors and for medical staff assistance. The idea is based on wearable robotics and computing technologies which is an emerging technology now a days. The vest is designed to convert medical process in the field of automation where tasks are highly precise and perfect to prevent the medical errors in hospitals and convert the whole data based into a cloud which can be accessed by medical staff and doctors at any time and will be updated automatically after each medical or diagnosis process. This project is a kind of electronic jacket, which can be used for reducing medication errors. By the help of smart vest we have automated the hospital wards, reduced the burden on the nurses and doctors and ensured the safe and proper medication of the patients. The orthodox method used in hospitals is that patient's record and history is maintained on paper, nurses and doctors can easily commit errors because of this kind of database. However the developed countries have come up with the idea of medication cart which after further improvements can become robot to reduce medication error which could operate automatically without the help of any human being. However this smart vest after further enhancements can become more efficient and even then it would require nurse etc. which means empowering the staff only, this would not reduce the humans, and man power would be used efficiently.

KEYWORDS

Medical errors, Administration errors, Electronic prescribing, Wearable robotics and computing devices, Cloud data base.

I. INTRODUCTION

Human life is precious and errors at any stage of medication or diagnosis cannot be accepted. Medical Errors are the leading cause of death in hospitals around the world. The report apparently shows that the Medical errors [1] are responsible for injuries in as many as 1 out of every 25 hospital patients. An estimated 48,000-98,000 patients die because of medical errors each year. Errors in health care have been estimated to cost more than $5 million per year in a large teaching hospital and preventable health care-related cost the economy from $17 to $29 billion each year. They are increasing exponentially because population of world is increasing day by day and so the number of patients in hospitals. These circumstances have made the hospitals to grow more huge but still congested. Under these circumstances it is becoming very difficult for medical staff to manage and controls the medication processes of each patient.

A European survey [2] was conducted on medical error gave very alarming results. Table in Fig.1 shows the result when people were also asked whether they have either personally or in the family experienced a serious medical error.23% of Europeans state to have been directly affected by a medical error personally or in the family. 18% indicate that they or their family members have experienced a serious medical error in a hospital whereas 11% announces having been prescribed wrong medication. Roughly, it can be stated that in countries with fewer incidents in hospitals also the number of misconducts with medication are rarer. In general, incidents in hospitals appear to be more common than incidents of unsuitable medicines. The highest numbers of experienced incidents in hospitals are found in Latvia (32%), Denmark (29%) and Poland (28%).
In order to handle such type of problem number of solutions were made. The most famous one was a medical trolley for closed loop electronic prescribing and administration system

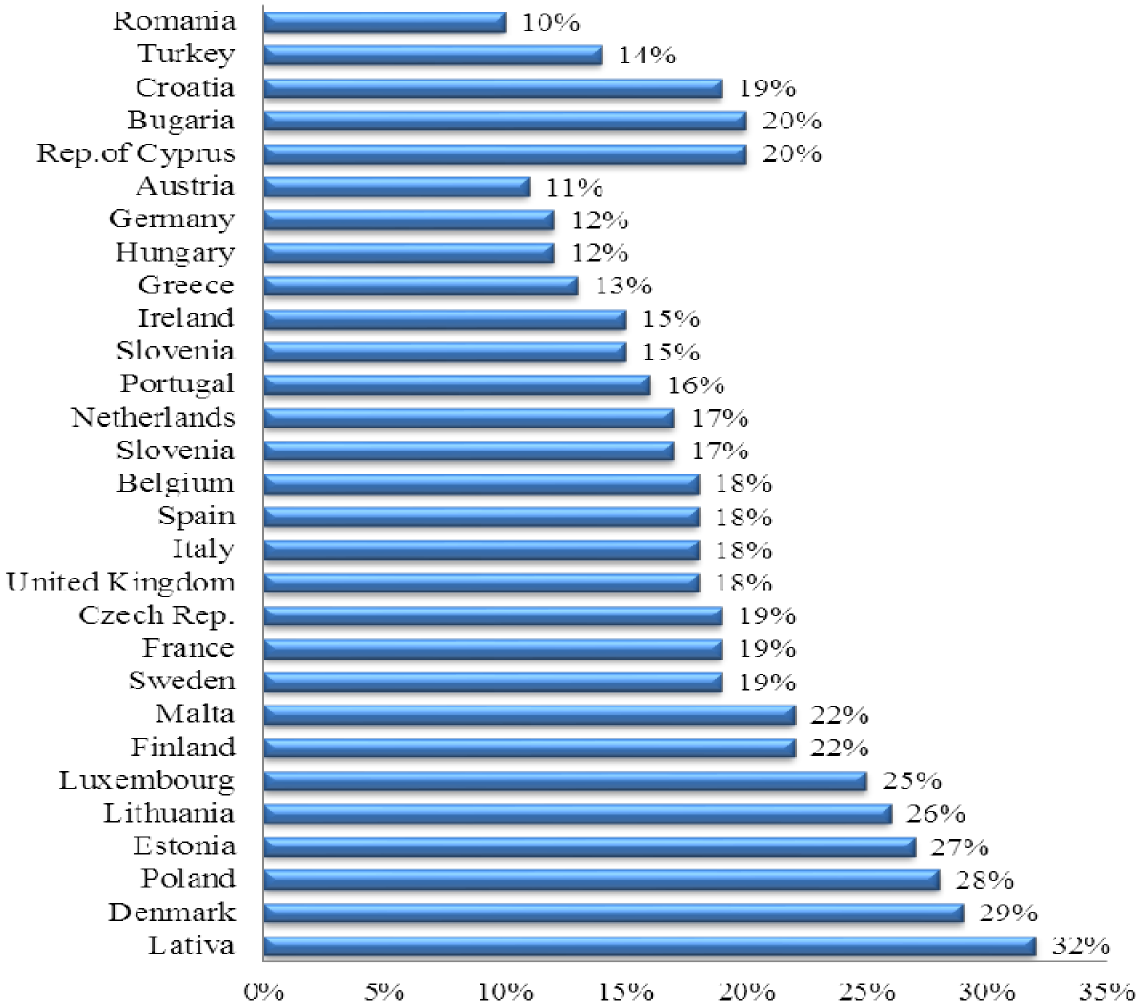


Fig.1 Survey Graph

[3] but this solution flopped due to their bulky size and cost. The system comprised the following three elements.

1. Electronic prescribing, scheduling and administration software
2. Ward-based automated dispensing
3. Electronic drug trolleys

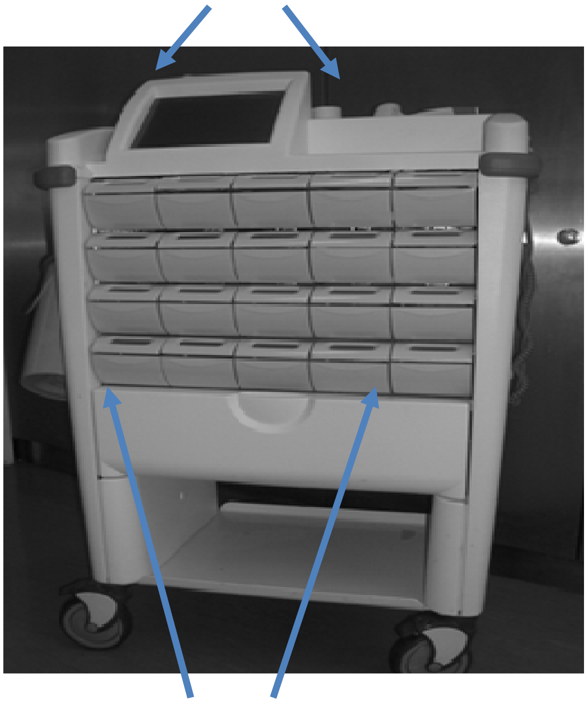


Fig.2 Electronic Drug Trolleys

Software was window based and it carries all the prescription information of patient. The majority of medication was stored in large automated cabinets the required drugs were transferred by nursing staff to an electronic drug trolley at each drug round. There were two electronic trolley each have twenty draws. The barcode on each patient's wristband was scanned during each round which enables the system to open that patient's drawer in the trolley so that the medication could be given. This solution was good but to implement such solution in underdeveloped countries is not possible. This system has following draw backs.

1. Not cost effective
2. Not rapidly reproducible
3. Skilled crew required
4. Big Foot Print

II. DEVELOPMENT OF THE DESIGN

The main objective of our project is to use the wearable robotics and computing devices for electronic prescription, administration system, control all the processes involve in diagnoses, create a data base of all patient which will be automatically updated after each medical session and diagnosis, prevent the errors involved during medication and diagnoses and provide assistance to the medical staff. Initially different experiments were made to create a better design to provide better results.

2.1. Vest Material

On the bases of different experiment it was decided to design a vest with parachute material which will provide strength to the design and whole system will be water proof, so there will be no short circuiting or conduction due to any liquid especially sweating. Vest is based on two layers of parachute. All wiring and connectors are between these two layers which ensure that no connection is externally visible and the whole system is safe. The layout of the system is shown in Fig.3.

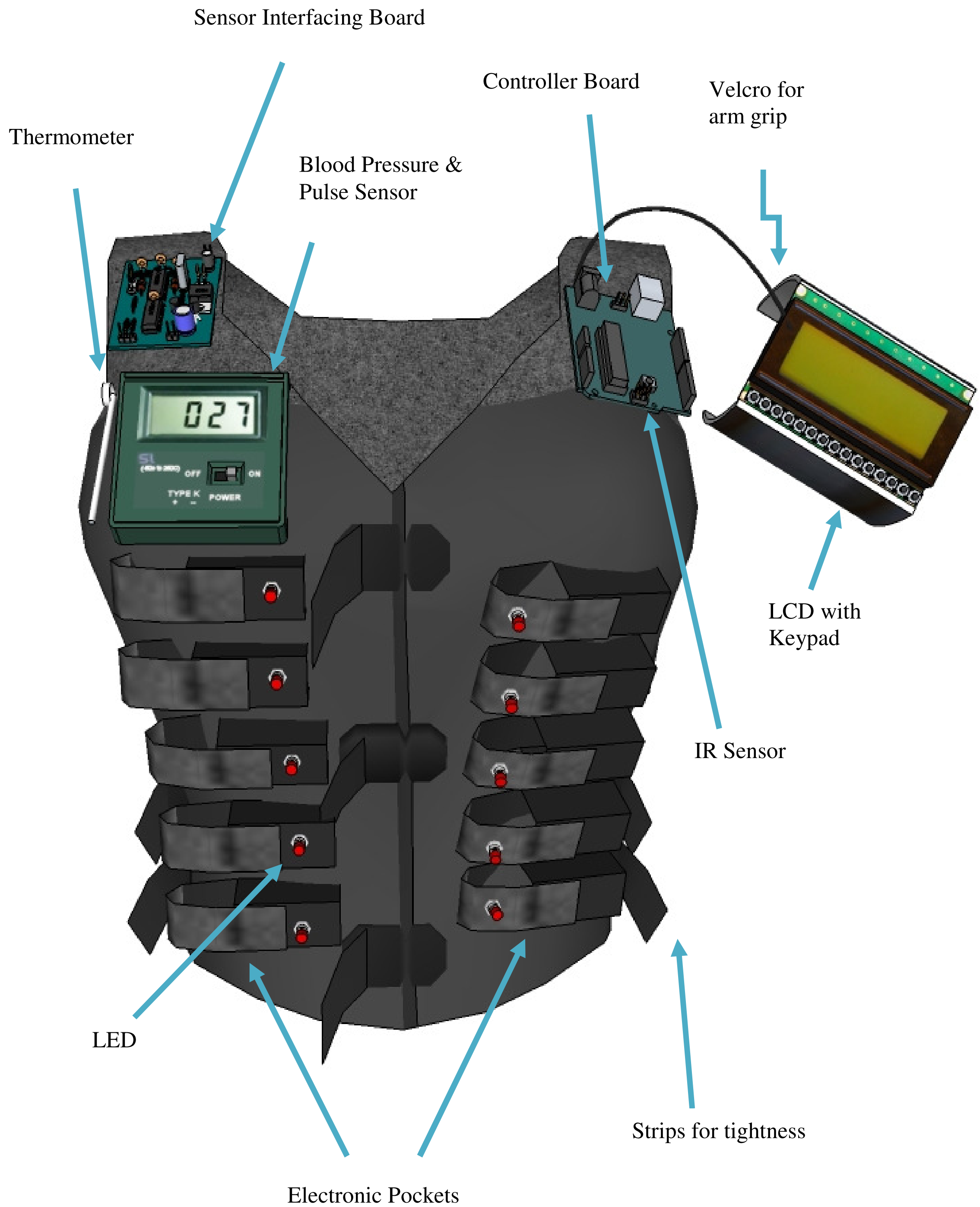


Fig.3 3D Smart Vest Design

2.2. Pockets Designing

As in the case of medical trolley, twenty drawers were used to carry the medicines of a particular patient but in case of Smart Vest each pocket will carry a particular medicine. On the top of each pocket there is a LED (Light emitting diode) which will indicate that this is the medicine, prescribed by the doctor. If nurse tries to open the wrong pocket (which is not glowing) an alarm will be generated which will notify him/her is trying to deliver wrong medicine. So it was necessary to design the pockets in such a way that maximum number of pockets can accommodate inside a single vest. So a pocket's layer approach was adopted to tackle this problem that opening of each pocket should be visible at the front view and rest of the pocket should lay between the two layers of parachute and by repeating this maximum number of pockets can be achieved. Roughly if we make columns on both

sides maximum 28 pockets can be made on a single vest. But for the sake of simplicity we made one column on both sides of the vest having six pockets in each column that means total twelve pockets as shown in fig.3.

2.3. Electronic Embedding

Size of electronic components plays a very major role here as, our aim is to create a smart, light weight flexible and effective vest. To handle this problem, circuits were designed very small in physical dimensions using advance circuit designing techniques and multilayer PCB (Printed Circuit Board).Another problem was that where we should place electronic(Microcontrollers, Sensors etc.) parts. Different ideas were considered in this case as medical staff can damage the system during his\her routine activities in hospitals. To make the design more suitable, all the electronic devices were fixed on both shoulders. Human interfacing kit is carrying a keypad and LCD (Liquid Crystal Display) around the left arm. This makes the smart vest very user friendly to the medical staff for performing their duties. Further the whole system is more flexible to use as all sensors (Thermometer, Blood pressure meter, Pulse meter) are on the front right side of the vest and human interfacing kit is around left arm which is easily visible and accessible.Fig.3 describes the whole theme more clearly.

III. HARDWARE DESIGN

While selecting hardware components, as described earlier it was our major focus to reduce the size as much as possible. Because later on all the electronic components will be embedded in vest.

3.1. Selection of electronic components

Microcontroller which are the core of any electronic project our purpose was to select a product which is enough capable to provide processing speed to our project and have minimum size as much as possible. So we decided to use AT89C2051 which is 20 pin package from 8051 family and is enough capable of providing processing speed to smart vest. 20x4 LCD is selected which provide enough space to display information and can be adjust around the arm easily. For storage of data base and real time clock 24C64 and DS1302 are selected respectively because of their less physical dimension. For wireless patient detection IR sensors are selected to have less complexity, small size and suitable range. In order to reduce the electronic size and to save the microcontroller’s pin shift register (74HCT164) and 3 to 8 decoder (74HCT138) is used.

3.2. Efficient hardware designing

During circuit designing by using optimization techniques we reduce the physical size as much as possible. Two major controller boards are shown in Fig.4 and 5. One board is used for human interfacing, having 4x20 LCD, 4x4 keypad and serial communication with the Data Storage Board. While designing the Boards we considered many factors including the safety, size and efficiency. Combination of resistor, capacitor, power switch and LM7805 is used to provide DC voltage (5V) to the controller without damage. Buzzer is use for the alarm purpose, which is utilized in accordance with the requirements which will be explained later. Similar another board is used with a Shift Register (74HCT164) to interface LEDs and monitor each pocket.

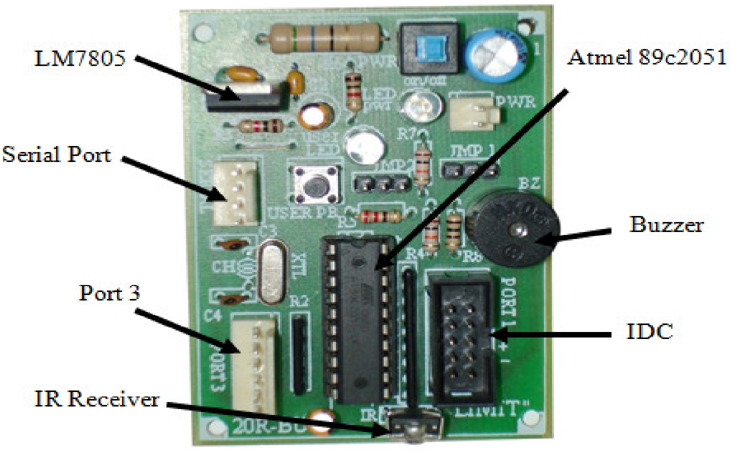


Fig.4 Generic AT89C2051 Controller Board

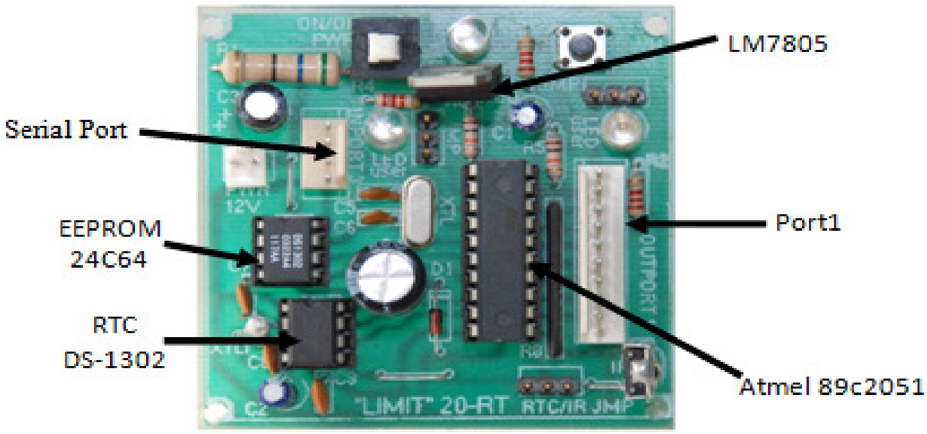


Fig.5 Data Storage Board

As the name indicates the Data Storage Board is used to store all the information about the patient including the Bio-data, information about the disease, medical history and medication. We used the EEPROM (24C64) as its size and storage capacity are met with our requirements. Another major component in this board is RTC DS1302 which is used as a real time clock

3.3. Medical sensors

To measure patients temperature, blood pressure and pulse rate Rossmax S150 [4] is decided to use to its unique features that is small size, single package contain all three sensors, easily available and Smart sense Technology. Smart sense technology utilizes an advanced air control system.

Fig.6 Rossmax S150

The electronic deflation valve precisely controls the deflation and allows the monitor to detect and analyse pulse signal, adjusting cuff pressure during deflation. This ensures more precise analysis while reaching maximum accuracy.

3.4. Initial system designing

In human interfacing system we interfaced 4x4 keypad to 74HCT138 by using only 6 pins of the microcontroller. An LCD of 4x20 is also used for the display. It is efficiently inter-faced with the Port1 in 4-bit mode. While selecting the LCD our main concern was the size and speed, so we have selected this LCD as it's very speedy and it can be easily adjustable on the arm of the medical staff. Similarly the data storage board is interfaced with the Generic controller Board using efficient serial communication. For creating a data base (Patient Profile) in 24C64 memory is divided in different sectors and section each sector presents the database of a particular patient and all the relevant information is contained by section present in each sector. Patient profile is shown in Fig.8.To include time tags related to patient bio-data. DS1302 is used as a clock, after every diagnosis processes this time tag is attached with the data base to give information when this process was done. System is designed for eight patients and for each patient detection, IR tegs are used which are working on RC-5 proto-col. An IR remote is designed for this purpose. IR transmitter is used to transmit the ID of the patient which is assigned to each patient during the admission. We have used 1-8 buttons of remote for the patient IDs, as our system is designed for 8 patients. In case of large number of patients combination of numbers (2^8) can be used. The keypad is used to operate the LCD to access the patient's data.

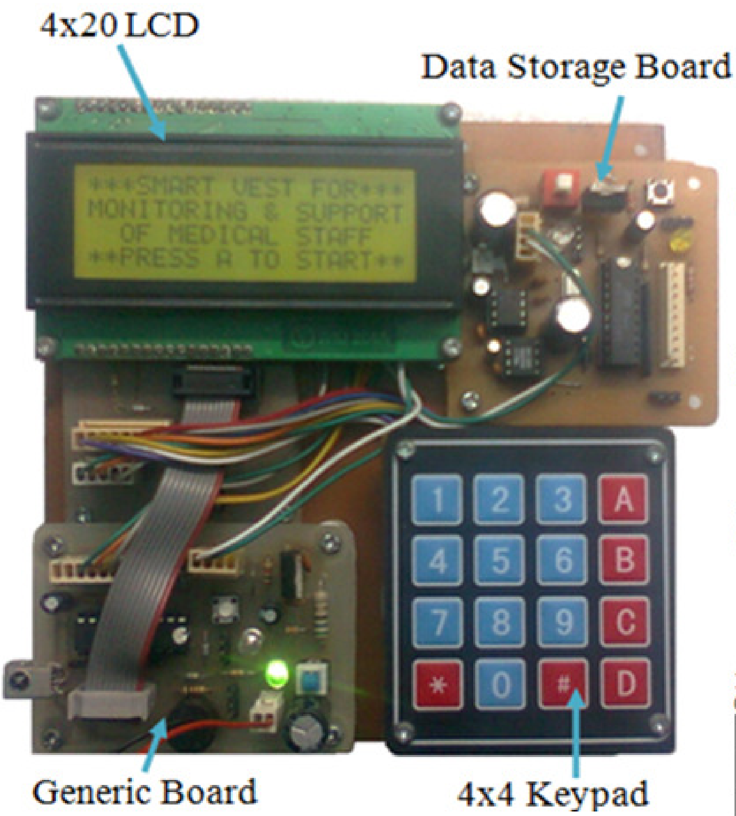
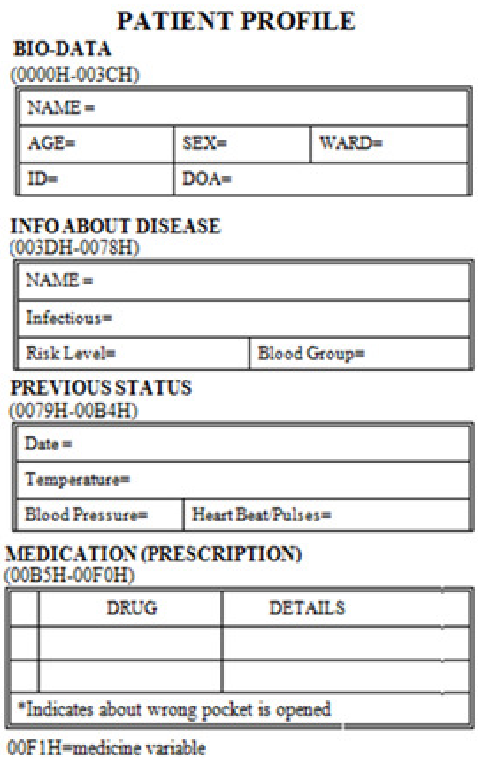


Fig.7 Initial System



PATIENT PROFILE

BIO-DATA
(0000H-003CH)

NAME =		
AGE=	SEX=	WARD=
ID=	DOA=	

INFO ABOUT DISEASE
(003DH-0078H)

NAME =	
Infectious=	
Risk Level=	Blood Group=

PREVIOUS STATUS
(0079H-00B4H)

Date =	
Temperature=	
Blood Pressure=	Heart Beat/Pulses=

MEDICATION (PRESCRIPTION)
(00B5H-00F0H)

	DRUG	DETAILS
*Indicates about wrong pocket is opened		

00F1H=medicine variable

Fig.8 Patient Profile

3.5. Modification in system

initial system design it was not possible to adjust a LCD board having a 4x4 keypad in vest.so to tackle this problem we used double side PCB board to reduce the size as much as possible as compare

to precious one by embedding devices on both side of PCB. And instead of using a 4x4 keypad we made a keypad by using seven push buttons which are enough for this system. Board is shown in Fig.9 so now we can adjust this module around left arm.

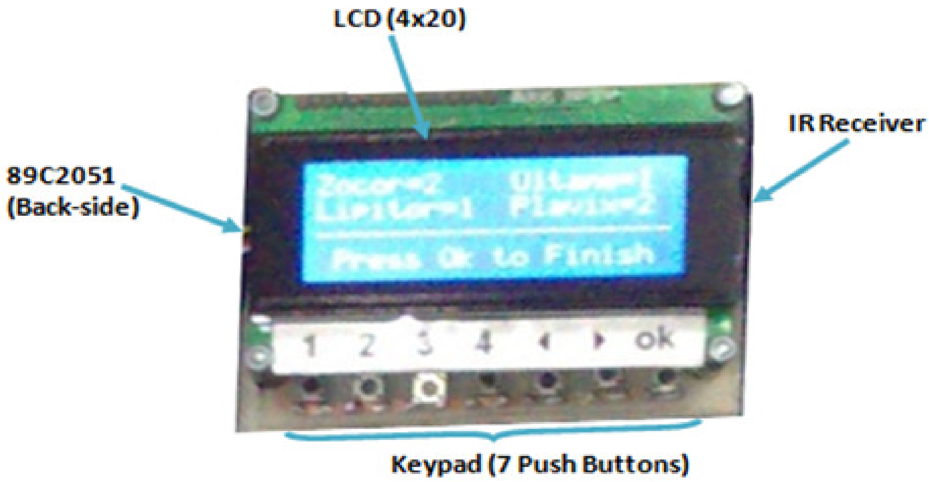


Fig.9 Modified module

3.6. Final system designing

While designing our final systems the basis requirement was the system design that can be efficiently embedded in the vest shown in the Fig.11. Also the pockets are designed in a clever way to imbed maximum pockets in the both sides of the vest.

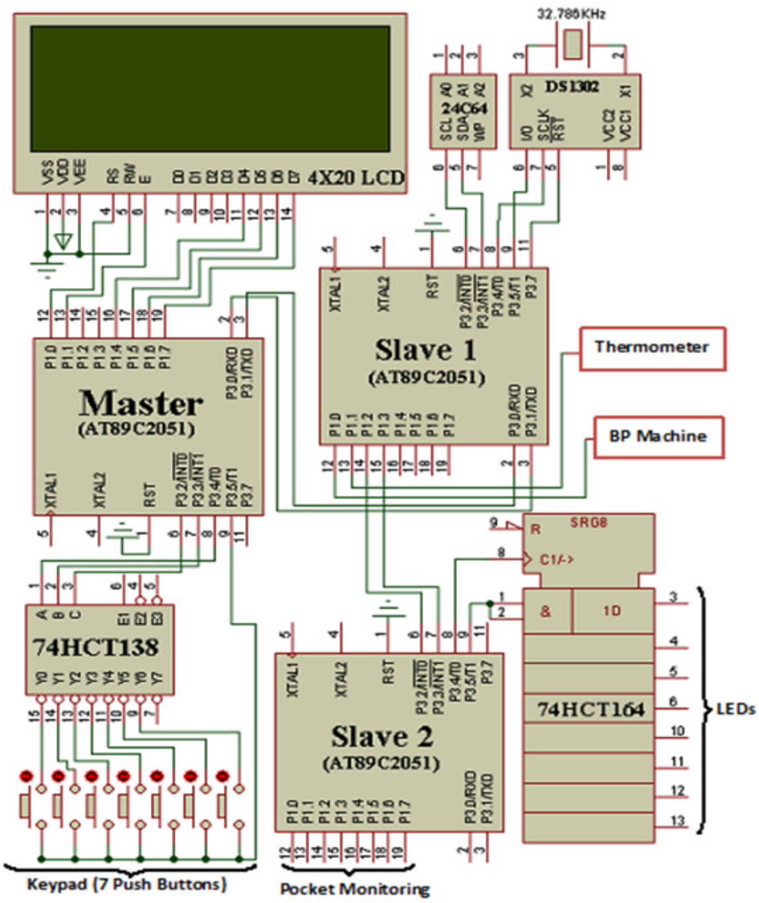


Fig.10 Schematic of System

IV. SYSTEM WORKING

The overall system is divided into different steps and modules each is performing its specific task as explained below.

4.1. Overall system flow and working

The sequence of the processes in the system is shown in fig.9. Overall system consists of 5 processes; each process has further sub-processes which will be explained under next section. In first step the nurse will identify the patient using his/her ID which is 0-8 in our system. Right patient identification will lead to the next process of patient's history and prescriptions advised by the doctor which are fed to the memory (EEPROM). These prescriptions will lead to medication after the diagnostic process. The diagnosis includes the temperature, blood pressure and pulse reading of the patient. After the diagnosis the measures values will be fed to the memory which guide the nurse which medicines should be delivered to the patient. When this data is send back to the memory, the memory will send the information about the pockets having the desired drugs. The desired pockets will be light up to make it easy for the nurse to identify the desired pockets containing the prescribed drugs. Here comes the pocket monitoring process. This is very important task as this will ensure the required drug delivery. It will continuously monitor the pockets which are not allowed to be open (undesired pockets). When the nurse will open the undesired pocket the alarm will be generated and will remain ON until the after all these processes the nurse will update the patient's previous history with the new measured values including time, and date. The whole system will flow in a ring, after status update there will be an option whether there is another patient or not. The system will be jumped to the next patient if there is any or will end in case of no other patient. The whole system is working in a main loop. Further nested loops are also there to handle the other sub-systems involved.

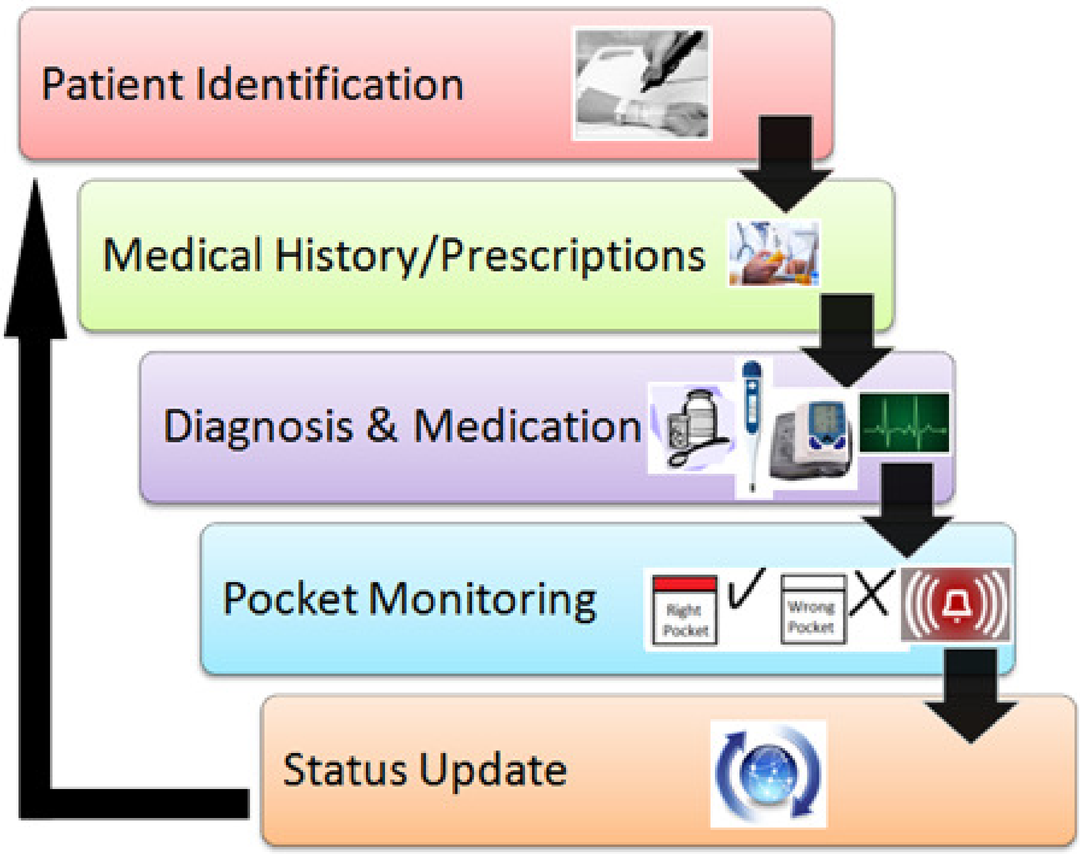


Fig.12 Major Processes of System

4.2. System flow chart

This is detailed system flow chart having all the sub-systems involved. The sub-systems of the main systems are in the same coloured as in the Fig.12.

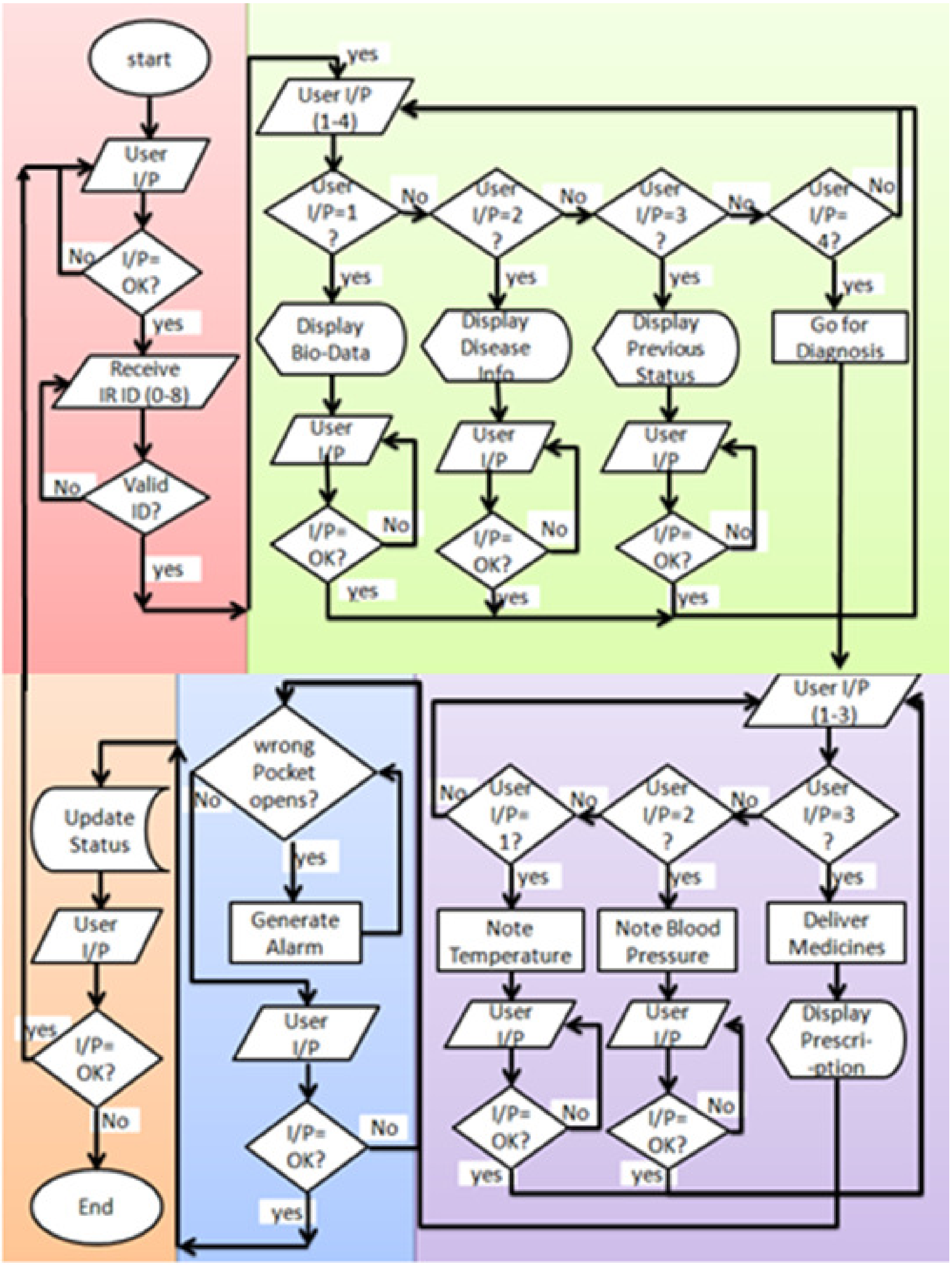


Fig.12 Major Processes of System

V. FUTURE MODIFICATION

To implement this idea practically in hospitals we can create a GUI based software. The doctors will access entire data-base stored in EEPROM by using a Bluetooth device or by creating a database cloud service. A Bluetooth device is used which will transmit all the information to the cloud which can be access by all the Vests. The purpose of doing this that doctor can view the profile of their patient and can add or remove medicines according to their present status without doing check-up of patient personally on their Computers. This will provide relaxation to medical staff and completely

atomise the medication process. So there are less chances of error. Another modification which can be made in the design is the number of pockets. As shown in Fig.8. The pockets are designed so that large number of pockets can be added in a two columns at each side, having 14 pockets in one column, hence total number of pockets can be up to 56.

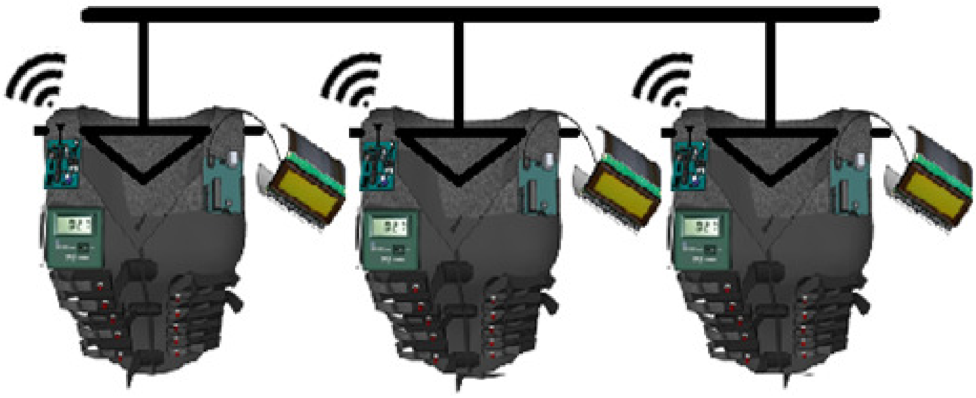


Fig.14 Vest with Vocal Interface

We can add speak-jet IC and a speaker to this project for vocal interface so jacket will vocally guide the nurse. And nurse will follow the process tree prescribed by the doctor so by doing this vest will completely transform a layman to a doctor. Such type of jackets can be used by emergency squad or rescue team to provide medical facility in emergency and vest can be controlled by a wireless link at a remote end and for visuals we can add wireless camera so a professional medical can view the situation and send commands to vest from a remote end and vest will guide the person which step he/she should take and similarly medicine etc. Furthermore for the sake of above described modifications we have dedicated the pins of data-storage board for the interfacing or any other modification according to the future requirement to avoid the large hardware changing for any small additions.

VI. CONCLUSIONS

A complete smart and efficient system is designed including all aspects of medical trolley with some additional modification and atomization techniques.

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